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(56) Documents cited
GB 2184627 A GB 1453451 A EP 0249292 A
US 4683474 A US 4291310 A US 4048637 A

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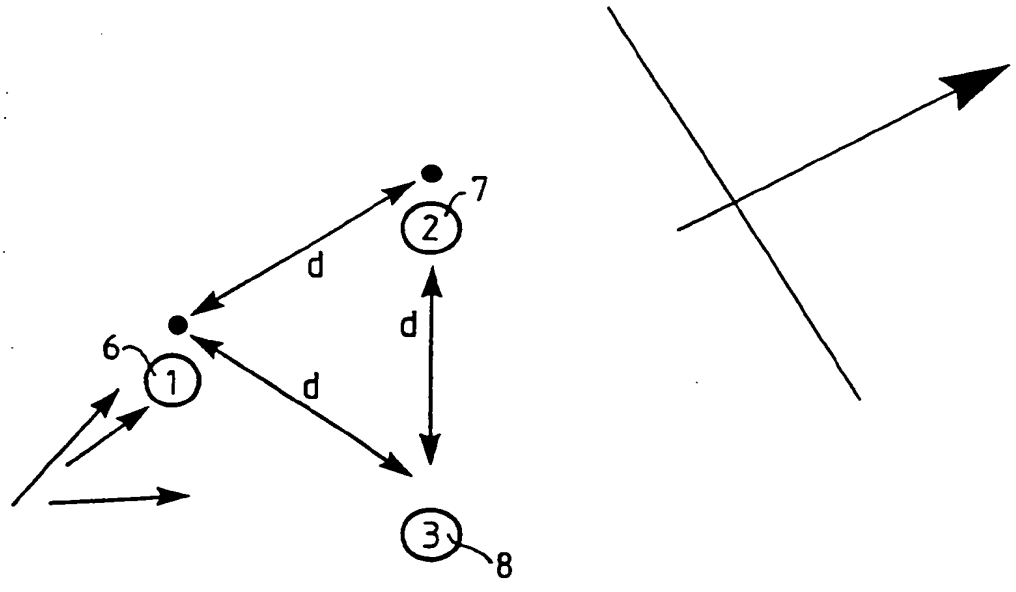
(54) Mobile bistatic radar

(57) The receiver comprises a plurality 6, 7, 8 of spaced antennae. The transmitter provides a click pulse, whose azimuth after reflection by a target is determined by the relative times of arrival (Fig. 3) of the pulse edge at the antennae. From the direct pulse edge arrival time, compared with that via the target (Figs. 4, 5) an isochronous ellipse is known, whence, given the azimuth (A), the range is determined. Vertically spaced ring antennae (Figs. 6, 7) enable the elevation to be determined. The transmitter (1 Fig. 1) position may be coded onto the pulses. The receiver(s) are passive fire units.

FIG. 2.



At least one drawing originally filed was informal and the print reproduced here is tak n from a later filed formal copy.

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FIG. 1.

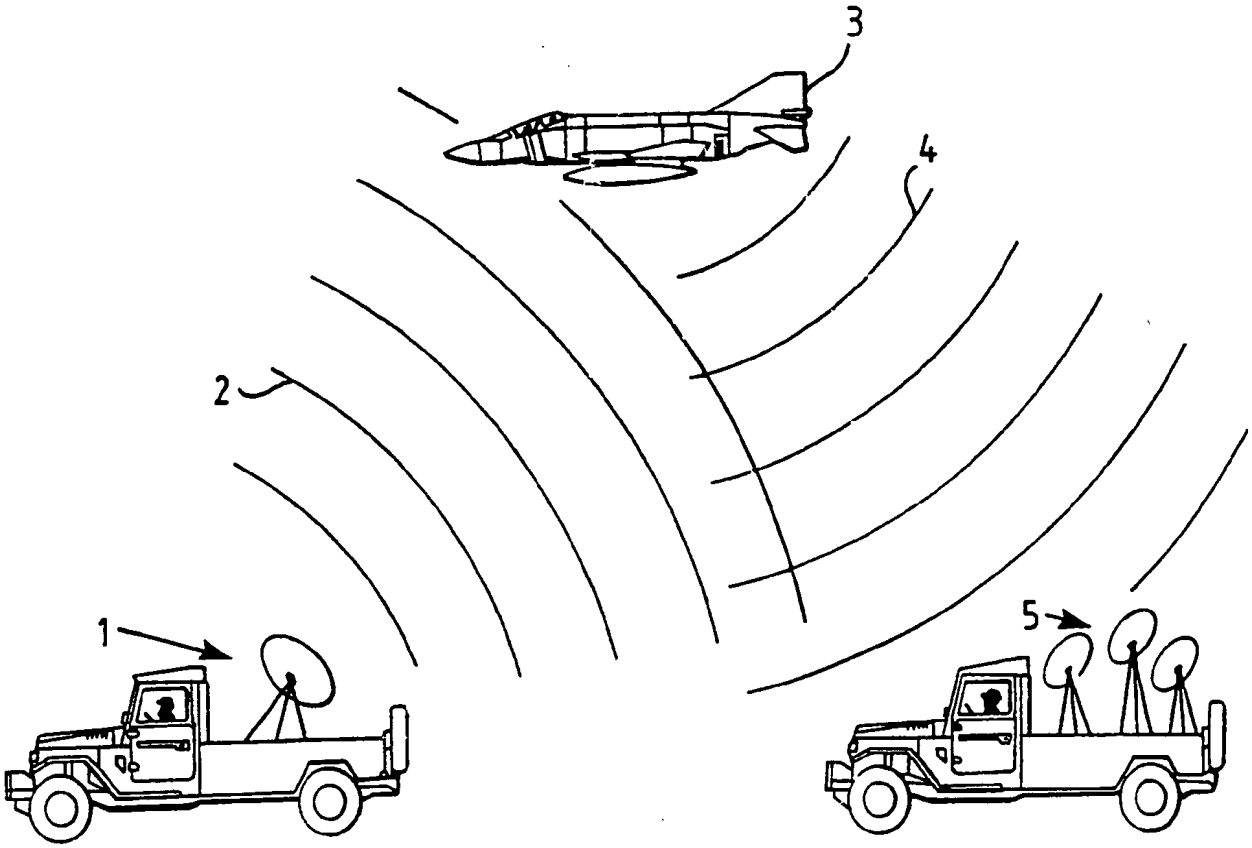


FIG. 2.

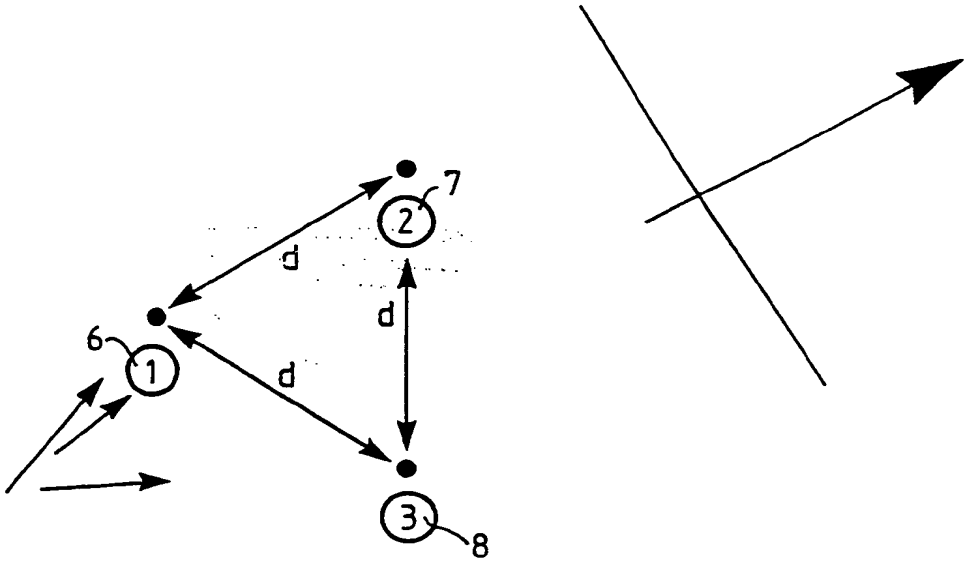


FIG. 3.

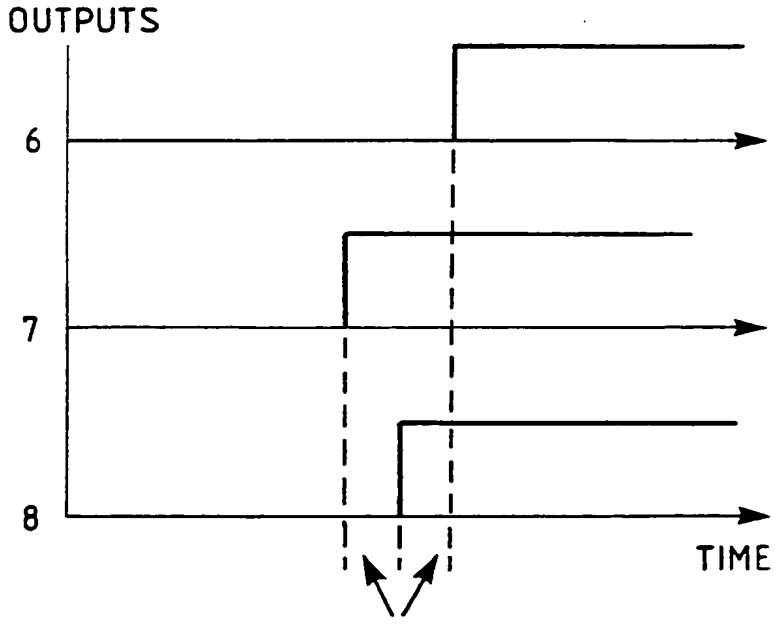
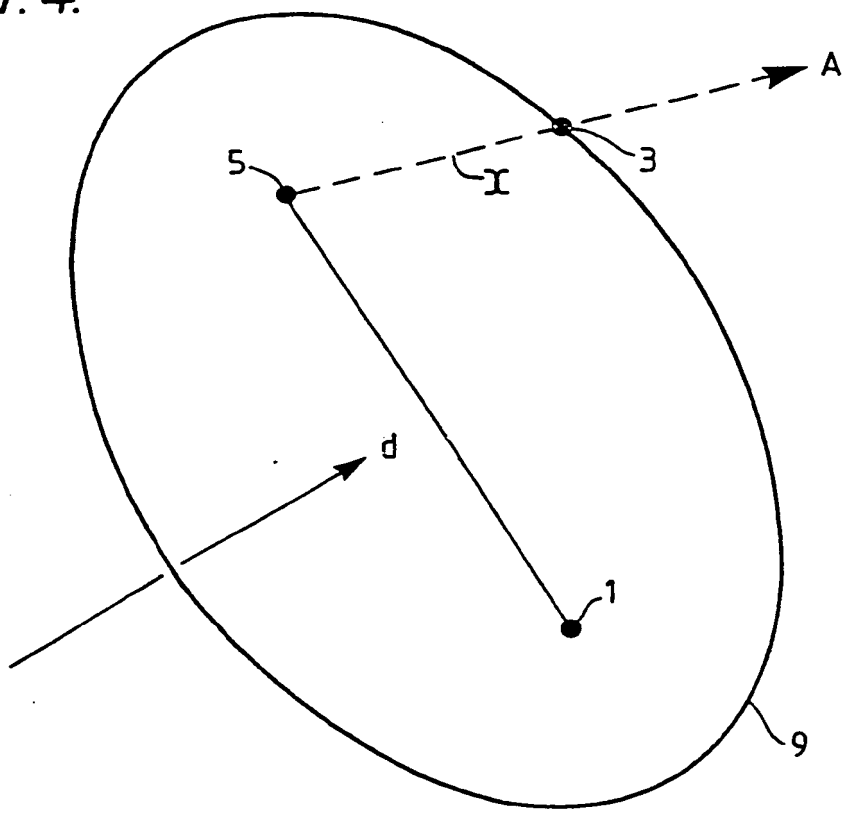


FIG. 4.



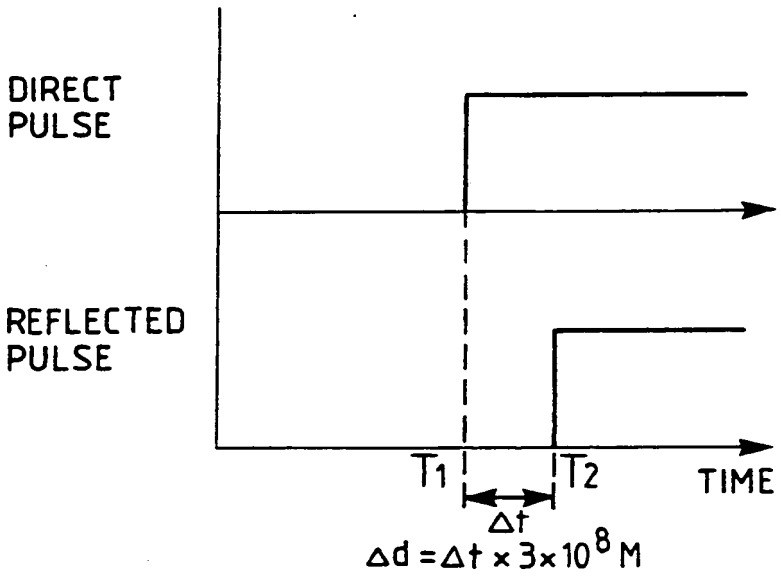


FIG. 5.

FIG.6.

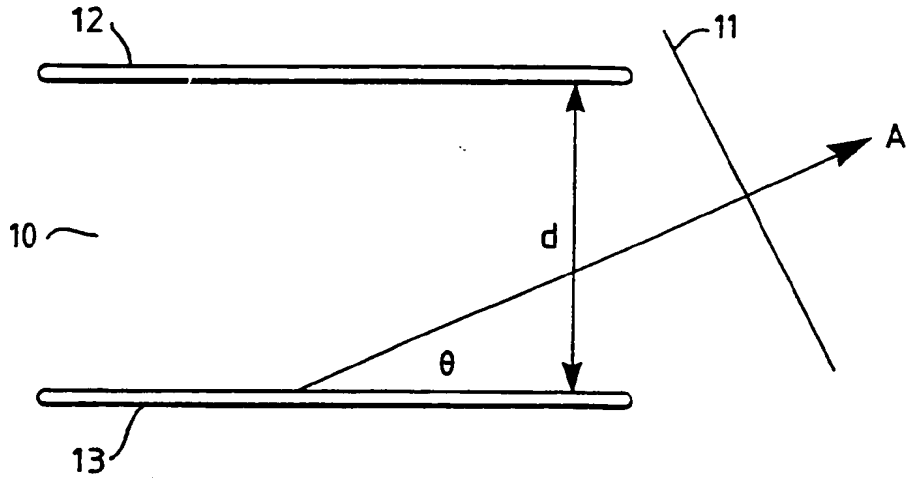
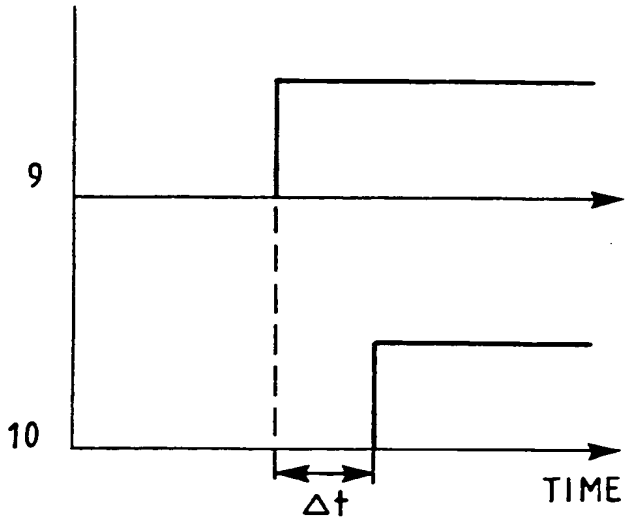


FIG.7.



RADAR SYSTEMS

This invention relates to a novel radar system which includes an ultra-short pulse (or 'click') radar.

In a modern ground war, mobility and non-disclosure are of vital importance. This is difficult to achieve with an all weather fire unit because of the need for it to carry radar surveillance and tracking systems. Bistatic operation of a radar is attractive but conventionally the location of the transmitter has to be fixed making it very vulnerable to counter attack and inappropriate to the mobile war. Weapon system reaction time is also vital and this generates the need to avoid lengthy setting up procedures and makes current surveillance radar systems fairly unattractive.

An object of the present invention is to provide a mobile bistatic radar system, which is capable of determining the actual position of all targets, receivers and transmitters, without revealing itself to the enemy.

According to one object of the present invention there is provided a radar system for detecting a remote target comprising:-

transmitter means for transmitting a click radar signal;

two or more adjacent receiver means for receiving said radar signal from said transmitter means and/or reflected from said target;

position location means associated with said transmitter means and said receiver means for determining the exact positions of the transmitter means and the receiver means;

encoding means associated with said transmitter means for encoding the position of the transmitter means to produce an encoded click radar signal;

time measurement means for measuring one or more time delays between receipt of the radar signal at one receiver means and one or more adjacent receiver means;

decoding means associated with said receiving means for decoding the encoded click radar signal to determine the position of said transmitter; and

computer means for determining the position of the target from said time delay measurements and the positions of said transmitter means and receiver means.

Reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a schematic diagram of a radar system according to the present invention;

Figure 2 is a schematic diagram of a direction finding antennae system for receiving radar signals from a target and as used in the Figure 1 system;

Figure 3 is a graph showing the time differences between the arrival of the radar wave at the antennae of the Figure 2 system;

Figure 4 is a schematic diagram for showing the relative locations of the target, transmitter and receiver and determining the location of the target;

Figure 5 is a graph showing the time difference at the receiver antenna array shown in figure 1, between the arrival of

a radar wave directly from the transmitter and the arrival of a radar wave reflected by the target.

Figure 6 is a side view of a target elevation measurement antennae; and

Figure 7 is a graph showing the time difference between the arrival of the radar wave at the upper ring and the lower ring of the figure 6 antenna.

Referring to Figure 1 a mobile transmitter 1 transmits a click radar signal 2. This signal 2 may be reflected by a target 3, and a reflected signal 4 be produced. The reflected signal 4 is then detected by a mobile antennae array 5.

The mobile antennae array may be as shown in figure 2, i.e. comprising three antennae 6, 7 and 8 positioned in a triangular orientation each separated from the other two by a distance d. A wavefront 9, reflected from the target (not shown in this drawing) reaches each of the antennae 6, 7 and 8 in turn. Figure 3 shows the arrival of the wavefront at each of the antenna, it arrives first at antenna 7, then antenna 8 and finally at antenna 6. Since the wavefront is travelling at the speed of light, the relative spatial positions of the antennae and the times at which each antenna received the wavefront are known then the direction of the target, shown by arrow A can be determined from simple geometry.

Referring to Figures 4 and 5, the actual location of the target 3 relative to the receiver 5 and the transmitter 1 can be found. If the transmitter is located at co-ordinate X_T, Y_T, and

the receiver is at co-ordinate X_R, Y_R, then the distance d, separating the transmitter and receiver is given by

$$d = \sqrt{((X_R - X_T)^2 + (Y_R - Y)_T^2)}$$

The time T_1 at which the direct pulse is received and the time T_2 at which the reflected pulse is received or known. Then the extra distance the reflected beam has travelled Δ d is found from.

$$\Delta d = (T_2 - T_1) \times C$$

Where C is the velocity of light. Since d and is known form the positions of elements 1 and 5 and since, Δ d are known the target must be located on the ellipse of the target 9. Hence the distance x from the receiver in the direction of arrow A can be determined.

Referring to Figures 6 and 7 a ring antennae shown generally at 10, may be added to the radar system in order to determine the elevation angle of the target.

the incoming wavefront 11 is received at the first ring antenna 12 before it is received at the second ring antenna 13. The time delay Δ t is related to the target elevation angle Θ by:-

$$\Theta = \sin^{-1} \frac{\Delta t \times C}{y}$$

where C is the velocity of light and y is the separation of antennae 12 and 13

The outcome of the three step process is that a 3D passive radar is provided.

Once the target position has been established approximately with the surveillance device described it is then possible to steer

a high gain antenna onto the target bearing. This can be used to track the target and provide more accurate angle information which is suitable for the guidance of missiles.

Bistatic operation allows the fire unit to be passive thereby making it less vulnerable to counter-attack.

The invention allows passive target tracking as well as passive surveillance.

The transmitter can be highly mobile and could transmit on the move.

Only one transmitter is required to 'service' a number of fire units.

The system can be adapted for use in a naval situation, with the receiver and transmitter being on the same vessel. Alternatively the transmitter may be on one vessel and the receivers on another. However due to the size of the vessels the receivers could be spaced further apart, this allowing a longer rise time on the click production i.e. using just a short pulse click radar not an ultrashort pulse click radar.

Both transmitter and receiver may carry a GPS (Global Positioning System) or similar location device.

The encoded position of the transmitter may be transmitted in any appropriate manner on the radar pulse signal.

No additional data links are required to convey the location of the transmitter to the receivers/fire units.

The front edge of the click pulse should ideally be shorter than the time taken for the pulse to be received at two adjacent points (i e say antennae 7 and 8). Hence the pulse rise time is

governed by the spacing of the antennae but will typically be of the order of 10^{-9}s. This would allow a separation of the order of 1m for the antenna 6, 7 and 8, and between antenna 12 and 13.

It should be noted that the transmitter and/or the receiver may be carried on any suitable carrier or vehicle, for example, a lorry, a tank, a missile launching vehicle etc.

CLAIMS

1. A radar system for detecting a remote target comprising:-

transmitter means for transmitting a click radar signal;

two or more adjacent receiver means for receiving said radar signal from said transmitter means and/or reflected from said target;

position location means associated with said transmitter means and said receiver means for determining the exact positions of the transmitter means and the receiver means;

encoding means associated with said transmitter means for encoding the position of the transmitter means to produce an encoded click radar signal;

time measurement means for measuring one or more time delay between receipt of the radar signal at one receiver means and one or more adjacent receiver means;

decoding means associated with said receiving means for decoding the encoded click radar signal to determine the position of said transmitter; and

computer means for determining the position of the target, from said time delay measurements and the positions of said transmitter means and receiver means.

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Pat nts Act 1977
Examiner's report to the Comptroll r under Section 17 (The Search Report)

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(ii) Int Cl (Edition 5) G01S

Search Examiner
G A MCLEAN

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASES: WPI, CLAIMS, INSPEC

Date of Search
28 DECEMBER 1990

Documents considered relevant following a search in respect of claims 1

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2184627 A (PLESSY) whole document	1
X, Y	GB 1453451 A (LITCHSTREET) especially lines 18-37 page 6; line 53 page 9 - line 9 page 11	1
Y	EP 0249292 (PHILIPS) especially line 10 column 16 - line 18 column 17	1
X, Y	US 4683474 (US) especially lines 3-14 column 3; line 58 column 4 - line 9 column 5	1
Y	US 4291310 (ITT) especially line 31 column 3 - line 41 column 4	1
Y	US 4048637 (WESTINGHOUSE) especially lines 10-19 column 3; lines 41-54 column 8; lines 1-19 column 9	1

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Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

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